Transhepatic approach: A safe alternative for left atrial appendage closure in challenging anatomical cases—A report of 2 cases and narrative review

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Introduction

Given that the majority of thrombi associated with atrial fibrillation (AF) in the left atrium originate within the left atrial appendage (LAA), historically, the surgical excision or exclusion of the appendage has been attempted as a prophylactic measure, albeit with initially elevated morbidity and mortality rates.[1]

While less invasive surgical interventions, such as minimally invasive thoracoscopic LAA occlusion, have been implemented for stroke prophylaxis in patients with nonvalvular AF, percutaneous transcatheter LAA closure (LAAC) demonstrates comparable efficacy in preventing strokes in nonvalvular AF patients.[2] Furthermore, the transcatheter LAAC is associated with significantly shorter hospital stays than the thoracoscopic procedure, although with a higher risk of bleeding events and thrombosis.[2]

Although transfemoral percutaneous vascular access remains the most widely used and preferred approach for LAAC, different approaches have been attempted when the anatomy of the appendage or the inferior vena cava (IVC) alters the angle at which the ostium of the appendage can be accessed. The transhepatic approach is a safe alternative when the transfemoral approach is unfeasible or otherwise contraindicated.

The percutaneous transhepatic approach for LAAC is a complex, multidisciplinary procedure requiring thorough cooperation between the electrophysiologist and the interventional radiologist. To our knowledge, only 7 LAACs have been reported using the transhepatic approach before.[3–9] We report 2 complex cases of patients requiring LAAC via a transhepatic approach. In the first case, it was indicated secondary to an isolated left-sided IVC; and in the second one, because of an occluded IVC. A comprehensive description of the surgical technique employed is included, along with a discussion of relevant anatomical aspects influencing the angle at which the appendage ostium can be accessed, which can determine the successful deployment of the closure device.

KEY TEACHING POINTS

- The percutaneous transcatheter closure of the left atrial appendage stands out as a safe, minimally invasive, and effective nonpharmacological alternative for stroke prophylaxis in patients with atrial fibrillation and elevated stroke risk.
- The transhepatic approach becomes particularly helpful in cases of occlusion of the inferior vena cava or iliofemoral venous systems and anatomical variations of the inferior vena cava.
- The transhepatic approach can be a safe alternative to transfemoral percutaneous vascular access when performing this procedure, particularly when the ostium of the left atrial appendage can only be accessed at a very acute angle.

Case report

First case

A 72-year-old man with a medical history including AF (CHA_2DS_2-VASc score of 4, HAS-BLED score of 3), dilated cardiomyopathy with complete heart block, a biventricular pacemaker and implantable cardioverter defibrillator, and

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prior endovascular repair of an aortoiliac aneurysm was considered unsuitable for oral anticoagulation owing to a propensity for easy bruising and bleeding. Consequently, the decision was made to proceed with percutaneous LAAC via a transfemoral approach. An unexpected anatomical variation was encountered during the procedure: an isolated left-sided IVC. This anatomical alteration resulted in significant tortuosity and posed substantial challenges to accessing the LAA. Repeated attempts to navigate the transseptal WATCHMAN FXD (Boston Scientific, Marlborough, MA) double-curve introducer sheath with the closure device resulted in a very acute angle entering the LAA, causing a kink in the sheath, narrowing its lumen, and obstructing the advancement of the closure device. A separate transseptal puncture at a lower and inferior septal location did not change the access to the LAA. The kink in the sheath obstructing the advancement of the closure device persisted even after attempts from the right and left femoral veins (Figure 1 and Supplemental Video 1). Subsequently, the procedure was aborted.

After consultation with the interventional radiologist and the patient, a second procedure was scheduled using the transhepatic approach. Under general anesthesia, the second procedure was done in the electrophysiology suite after an interventional radiologist obtained the transhepatic vascular access under sterile conditions.

Via a right internal jugular vein approach, a right distal hepatic vein of suitable size and caliber for percutaneous access along the right axillary line was identified using a Berenstein catheter (Merit Medical Systems, South Jordan, UT) (Figure 2).

Once the vascular access in the suitable vein was safely obtained, a wire was advanced to the right atrium. A 6F CLASSIC sheath (Merit Medical Systems, South Jordan, UT) was advanced over the wire. After that, a J-tipped GuideRight (Abbott, Chicago, IL) guidewire was advanced through the 6F sheath into the superior vena cava. Once this was done, a Swartz LAMP (Abbott, Chicago, IL) transseptal guiding introducer was advanced over the wire in the superior vena cava. The introducer was then dragged down into the right atrium, where the site of the transseptal puncture previously performed during the femoral approach was identified in the atrial septum. The guidewire was then advanced through the puncture site into the left superior pulmonary vein. Intravenous heparin (a bolus of 100 units per kilogram and additional doses as needed) was given to achieve and maintain an activated clotting time above 250 seconds. Subsequently, the transseptal guiding introducer was advanced over the wire into the left atrium. The guiding introducer was exchanged for a 15F WATCHMAN FXD double-curve sheath. The left atrial pressure was measured and recorded (9 mm Hg), and a pigtail catheter was advanced via the WATCHMAN FXD sheath, engaging the LAA and advancing the sheath over it (Figure 3).

A 31 mm WATCHMAN FLX device (Boston Scientific) was selected based on transesophageal echocardiogram (TEE) and fluoroscopic measurements and carefully inserted into the LAA. The process involved 2 repositionings with partial recapture to ensure optimal placement. TEE images confirmed the device's proper positioning without any leaks.

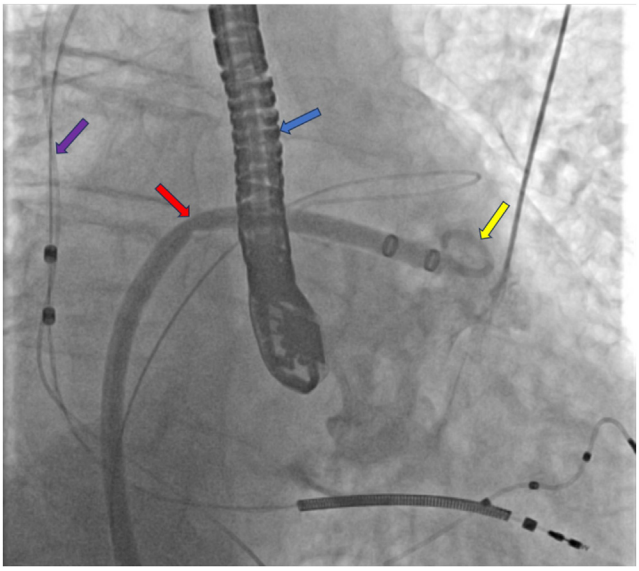

Figure 1 Right anterior oblique fluoroscopy projection during the initial transfemoral approach. In the fluoroscopy projection, the following features are identified: the transesophageal echocardiogram probe (*blue arrow*), both leads from the biventricular pacemaker and implantable cardioverter-defibrillator (*purple arrow*); the narrowing of the WATCHMAN FXD (Boston Scientific, Marlborough, MA) introducer sheath lumen (*red arrow*) via transfemoral approach, and a pigtail catheter delivering contrast material into the left atrial appendage (*yellow arrow*).

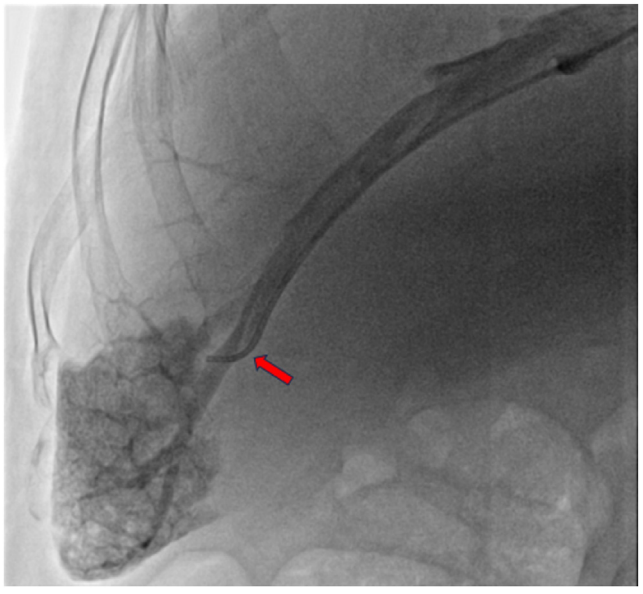

Figure 2 Right hepatic venogram. Contrast injection of a distal right hepatic vein to be used for the vascular access point for the transhepatic approach using a Berenstein catheter (*red arrow*).

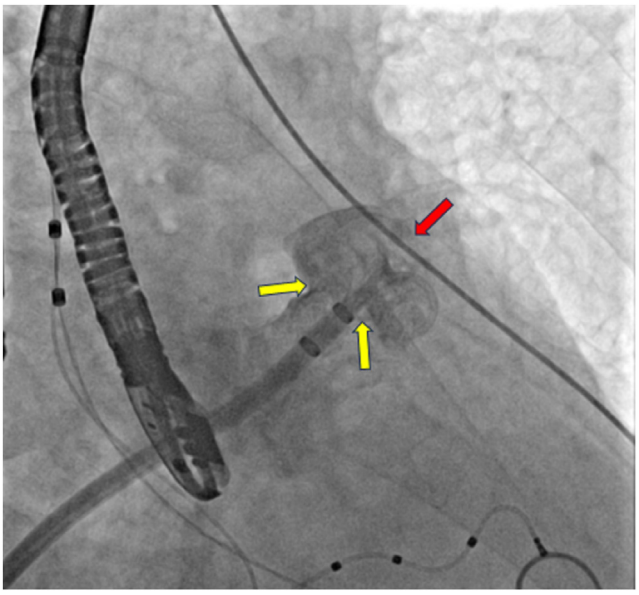

Figure 3 Left atrial appendage (LAA) contrast injection. Contrast injection showing an adequately sized LAA (*red arrow*), with a good delineation of its ostium (*yellow arrows*) and a coaxial orientation of the WATCHMAN FXD (Boston Scientific, Marlborough, MA) sheath via transhepatic approach.

Device stability was further verified through satisfactory compression values and a tug test.

Subsequently, a contrast injection was performed via the sheath, demonstrating an appropriate ostial placement with no peridevice leaks. The device was released uneventfully, and the WATCHMAN FXD sheath was returned to the IVC. At this point, the interventional radiologist took over to execute the vascular closure of the access site.

The WATCHMAN FXD sheath was exchanged for a 6F CLASSIC sheath, double-wired to maintain 1 wire as a safety precaution. Following a repeat hepatic venogram, a 7 mm Amplatzer Vascular Plug (Abbott, Chicago, IL) was deployed and positioned optimally. Another 6F CLASSIC sheath was introduced over the safety wire for a contrast injection behind the vascular plug, confirming the proper placement of the closure device. To ensure hemostasis, the access tract behind the vascular plug was sealed using Gelfoam slurry (Pfizer, New York, NY).

For thorough verification, a final venogram via the right internal jugular vein, using the Berenstein catheter, demonstrated excellent hemostasis and no contrast extravasation (Supplemental Video 2). The procedure concluded without complications, and the patient was discharged the following day after an uneventful overnight stay in the observation unit. Anticoagulation with rivaroxaban and antiplatelet therapy with low-dose aspirin were started the next day and continued for 45 days.

A follow-up appointment was scheduled for 1 week later, during which the patient reported no postprocedure complications or adverse events. At the 45-day follow-up, TEE revealed a well-seated device without peridevice leakage or thrombus formation. Rivaroxaban was discontinued, and dual antiplatelet therapy was initiated with low-dose aspirin and clopidogrel for 6 months, after which clopidogrel was discontinued, and low-dose aspirin only was recommended indefinitely.

Second case

An 82-year-old man with a medical history including AF (CHA_2DS_2-VASc score of 5, HAS-BLED score of 3), chronic kidney disease stage 3b (glomerular filtration rate of 37 mL/min/1.73 m^2), a history of venous thromboembolism, and the presence of an IVC filter, was deemed ineligible for oral anticoagulation owing to a tendency for gastrointestinal bleeding associated with small bowel arteriovenous malformations and was selected for percutaneous LAAC via a transfemoral approach.

Because the patient was found to have severe tortuosity of the bilateral iliac and femoral venous systems and occlusion of the IVC distal to the filter (Supplemental Video 3), the procedure was aborted. After consultation with the patient and the interventional radiologist, a second procedure was scheduled using the transhepatic approach.

Using the exact technique previously described, a successful LAAC implant was achieved using a 20 mm WATCHMAN FLX device (Supplemental Video 4). The procedure concluded without complications, and the patient was discharged the following day after an uneventful overnight stay in the observation unit. Anticoagulation with apixaban and antiplatelet therapy with low-dose aspirin were started the next day and continued for 45 days.

A follow-up appointment was scheduled for 1 week later, during which the patient reported no postprocedure complications or adverse events. During the 45-day follow-up, TEE revealed a well-seated device without thrombus formation or peridevice leakage. Apixaban was discontinued, and dual antiplatelet therapy was initiated with low-dose aspirin and clopidogrel for 6 months, after which clopidogrel was discontinued, and low-dose aspirin only was recommended indefinitely.

Discussion

The transhepatic approach for LAACs remains a complex and demanding procedure that requires multidisciplinary collaboration. To the best of our knowledge, our first patient represents the first reported case of LAAC using this approach in the setting of an isolated left-sided IVC. Furthermore, apart from the 2 cases presented here, only 7 other LAAC implants via transhepatic approach have been previously reported (Table 1).

Since there is limited evidence about using the transhepatic approach for invasive electrophysiology procedures in the adult population, most of what is known derives from studies done in pediatric populations, where it has been reported as feasible, with a low (<5%) complication rate.[10] According to Soto and colleagues,[11] among the reported complications associated with the transhepatic approach are hemothorax, transaminitis, liver hematoma, thrombosis of

Table 1 Cases reporting left atrial appendage closure implants via transhepatic approach

Authors & year	Age, y	Sex	Transhepatic approach indication	Periprocedural complications	Transhepatic access closure device	Follow-up after discharge	45-Day follow-up TEE	Complications during follow-up
Morcos et al 2018	86	M	Bilateral occlusion of the femoral veins	None	Not mentioned	Yes	Not mentioned	None
Huang et al 2019	64	F	Bilateral iliac vein fibrosis	None	Two Tornado MWCE 35-5/3 embolization coils (Cook Medical, Bloomington, IN) + 15 minutes of manual pressure	Not mentioned	N/A	N/A
van Niekerk et al 2019	87	M	Presence of IVC filter + complete IVC occlusion	None	One 12 mm Amplatzer Vascular Plug II (Abbott, Chicago, IL) + Gelfoam (Pfizer, New York, NY)	Yes	Not mentioned	None
Tandon et al 2020	82	M	Situs inversus + interrupted IVC	None	SURGIFOAM Absorbable Gelatin Sponge (Ethicon, Somerville, MA) mixed with saline	Yes	Well-seated device / no peridevice leak / no thrombus	None
Zare et al 2020	81	M	Bilateral occlusion of the iliac and femoral veins	None	Two 10 mm Amplatzer occluding plugs (AGA Medical, St. Paul, MN)	Yes	Not mentioned	None
Magnus et al 2022	77	M	Interrupted IVC	None	8 mm MVP, microvascular plug system (Medtronic, Minneapolis, MN) + Interlock-35, 10 mm coils (Boston Scientific, Marlborough, MA) + Gelfoam (Pfizer, New York, NY)	Yes	Well-seated device / no peridevice leak / no thrombus	None
Girgis et al 2023	78	M	Interrupted IVC	None	Two 8 mm Amplatzer Vascular Plugs type 4 (Abbott, Chicago, IL) + Gelfoam (Pfizer, New York, NY)	Not mentioned	N/A	N/A
Quiroz Alfaro et al 2023	72	M	Isolated left-sided IVC	None	One 7 mm Amplatzer Vascular Plug (Abbott, Chicago, IL) + Gelfoam (Pfizer, New York, NY)	Yes	Well-seated device / no peridevice leak / no thrombus	None
Quiroz Alfaro et al 2023	82	M	Occluded IVC	None	One 7 mm Amplatzer Vascular Plug (Abbott, Chicago, IL) + Gelfoam (Pfizer, New York, NY)	Yes	Well-seated device / no peridevice leak / no thrombus	None

IVC = inferior vena cava; N/A = not applicable; TEE = transesophageal echocardiogram.

the hepatic and portal veins, and infections like hepatic abscess.

We did not observe complications from the transhepatic approach in any of our cases. We used 1 Amplatzer Vascular Plug (Abbott, Chicago, IL) and Gelfoam (Pfizer, New York, NY) to assist with the hemostasis of both of our patients. Likewise, most similar reported cases where LAAC was performed using the transhepatic approach used a vascular plug, in addition to a hemostatic agent to assist with hemostasis after the closure of the vascular access; nonetheless, combinations of vascular plugs with coils and manual pressure have also been reported (Table 1).

Based on the findings of the other reported cases and our experience, these are the most common indications for considering an approach other than the femoral approach for LAAC: firstly, encountering difficulty in reaching the right atrium, either because of anatomical variations of the IVC (interrupted IVC, left-sided IVC) or because of obstructions affecting the IVC or the iliofemoral venous systems; secondly, experiencing difficulty deploying the LAAC device even after successful access to the right atrium and transseptal puncture owing to an acute angle of cannulation of the LAA ostium.

Although femoral access is generally feasible, it may present challenges in cases like our first one, where we successfully reached the right atrium for a transseptal puncture. However, owing to the extreme angulations resulting from the altered anatomy of the IVC, the angle at which the LAA ostium could be cannulated was very acute. Despite the possibility of cannulation, the narrowing of the sheath lumen impeded the advancement of the closure device, necessitating an alternative approach.

A similar scenario was reported by Ciobotaru and colleagues,[12] where a successful transseptal puncture using a transfemoral approach was achieved. In their case, the angle at which the appendage ostium could be cannulated was also very acute, preventing the delivery sheath from advancing beyond 1 cm of the appendage ostium. Although they eventually succeeded using a different alternative approach (transjugular), based on our experiences and an analysis of cases requiring a transhepatic approach, we recommend considering an alternative approach when faced with either of these scenarios: the unfeasibility of reaching the right atrium from the IVC or if the selected approach leads to reaching the appendage ostium at a very acute angle.

Although steerable sheaths may make the need for an alternative approach less likely, until they become readily accessible as part of the delivery systems for LAAC devices, adopting alternative approaches remains a valuable and, at times, necessary option for performing LAAC.

Conclusion

The transhepatic approach for LAAC is a complex procedure that necessitates multidisciplinary teamwork. To date, only 9 cases, including 2 of our own, have been reported. Although further evidence is necessary to draw definitive conclusions on the safety of using the transhepatic approach as an alternative to the conventionally preferred femoral approach, our findings and those reported by other authors suggest that it could be a safe option when the transfemoral approach is otherwise unfeasible. The most common indications for choosing this approach include anatomical variations of the IVC and occlusion of the IVC or iliofemoral venous systems.

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Appendix

Supplementary Data

Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.hrcr.2024.02.017.

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